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(54) SLURRY FOR CMP AND CMP METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain the subject slurry having a stable polishing characteristic in the vicinity of neutral condition and high selectivity between an insulation film and an electroconductive film, and capable of accomplishing control of dishing by including polishing particles comprising mixed crystal particles composed of silica and alumina.

SOLUTION: This slurry is obtained by including polishing particles comprising mixed crystal particles composed of (A) silica and (B) alumina. In this slurry, the mixed crystal ratio of the component B to the component A is pref. 1 to 9, and this slurry is pref. at pH 4 to 9. Further, it is desirable that ammonium peroxodisulfate or hydrogen peroxide is used in this slurry as an oxidizing agent because there is no need of changing the pH of the slurry within the range from 4 to 9. This slurry, as necessary, may include an oxidation retarder, polishing particles, dispersant, an organic acid or the like aiming at improvement of holding the particles on a polishing pad.

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CLAIMS

[Claim(s)]

[Claim 1] The slurry for CMP characterized by including the polish particle which consists of a mixed-crystal particle of a silica and an alumina.

[Claim 2] The slurry for CMP according to claim 1 characterized by the range of the mixed-crystal ratio of said alumina to said silica being 1-9.

[Claim 3] The slurry for CMP according to claim 1 characterized by setting pH as the range of 4-9.

[Claim 4] The slurry for CMP according to claim 1 characterized by including a pel OKISONI ammonium sulfate or hydrogen peroxide solution as an oxidizer.

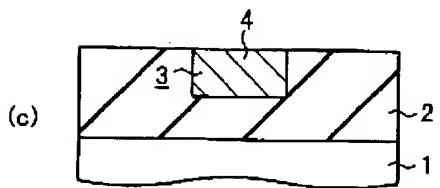
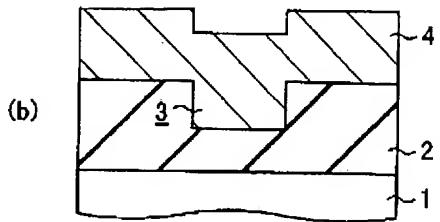
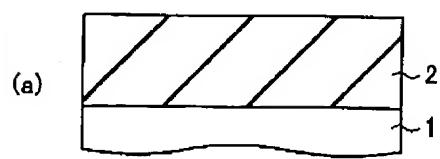
[Claim 5] The slurry for CMP according to claim 1 characterized by including the organic acid aiming at the improvement of maintenance of an oxidation inhibitor, a polish particle, a dispersant, and the scouring pad of a particle.

[Claim 6] The CMP method characterized by grinding the electric conduction film using the slurry for CMP according to claim 1 to 5.

[Claim 7] The CMP method characterized by making the interior of said slot save said electric conduction film selectively by grinding until the front face of said insulator layer exposes the electric conduction film formed on the insulator layer which has a slot using the slurry for CMP according to claim 1 to 5.

[Claim 8] Said electric conduction film is the CMP method according to claim 5 or 7 characterized by being the single-level-metal film which consists of a metal chosen from the metal group which consists of aluminum, W, Cu, Ti, Mo, Nb, Ta, and V, the laminated metal film or the alloy film which uses as a principal component the metal chosen from said metal group, a nitride, the HOU-ized film, or an oxide film.

[Translation done.]

Drawing selection [Representative drawing]

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the slurry for CMP effective in polish and the CMP methods of a metal membrane, such as aluminum film and W film.

[0002]

[Description of the Prior Art] In recent years, in the manufacture field of a semiconductor device, detailed-izing and densification progress and research and development in various ultra-fine processing technology is done. A CMP technique is an important technique it is [a technique] indispensable when forming DAMASHIN wiring also in it.

[0003] When the conventional technique performs metal CMP, the slurry which used the alumina particle as the base is used. The fact that there is polish capacity high to the alumina itself, that strong acid (pH:-2), such as a nitric acid, is used as an oxidizer in many cases, and the dispersibility of an alumina particle is good in this field, etc. is cited as that reason.

[0004] However, three problems shown below exist in the slurry of the alumina base.

[0005] In order for the 1st problem to grind metal membranes, such as Cu film and aluminum film, it is necessary to carry out pH of a slurry near neutrality but, and near neutrality, since dispersibility is unstable, I hear that it is difficult for the slurry of the alumina base to acquire the stable polish property, and it has it.

[0006] I hear that the 2nd problem cannot fully secure the selection ratio (a metal membrane polish rate / insulator layer polish rate) of the metal membrane to an insulator layer, and there is. When forming DAMASHIN wiring, it is necessary to fully secure the selection ratio of the metal membrane to an insulator layer. Therefore, generally he lowers alumina concentration and is trying to lower the polish rate of an insulator layer. However, since the polish rate of a metal membrane also falls simultaneously, it is difficult to obtain a high selection ratio, and it cannot control web thinning (film decrease of an insulator layer).

[0007] The 3rd problem is that dishing (retreat of Mizouchi's metal membrane film) is large. Especially, an exaggerated polish margin is small and the depth cannot form DAMASHIN wiring of homogeneity all over a wafer. Although the small hard scouring pad of elastic deformation is used as the cure, since it is in the relation of a trade-off to a blemish, in the case of a soft ingredient, it is difficult [it] like aluminum to solve, if a slurry is not devised.

[0008] Moreover, although the metal CMP using the slurry which used the silica particle as the base is tried, sufficient polish rate is not obtained or there are problems, like the morphology of a polished surface is bad.

[0009]

[Problem(s) to be Solved by the Invention] Although the slurry which used the alumina particle as the base was used with the conventional metal CMP like ****, when this kind of slurry was used, it could not be difficult to acquire the polish property stabilized near neutrality, the selection ratio of the metal membrane to an insulator layer could not fully be secured, and there were problems, like dishing is large.

[0010] This invention was made in consideration of the above-mentioned situation, and the place made into the object is to offer the slurry for CMP and the CMP method the high selectivity between the stable polish properties, insulator layers, and electric conduction film near neutrality and control of dishing are realizable.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned object, in this invention, what contains the polish particle which consists of a mixed-crystal particle of a silica and an alumina as a slurry for CMP (only henceforth a slurry) is used.

[0012] According to research of this invention persons, CMP using the slurry whose polish particle is a mixed-crystal particle of a silica and an alumina had the large load dependency of a polish rate, and it turned out that the increment in dishing can be controlled effectively.

[0013] Moreover, as for this kind of slurry, by setting the mixing ratio of the alumina to a silica as the range of 1-9 showed that the selection ratio of the insulator layer to the selection ratio of the electric conduction film to an insulator layer or the electric conduction film could be enlarged enough, and the high selectivity between an insulator layer and the electric conduction film could be taken regardless of pH of the slurry for CMP.

[0014] Furthermore, when this kind of slurry set pH as the range of 4-9, it turned out that aggregation service-ization (reversible condensation which can return to origin even if it condenses) of a polish particle can be realized, and the polish property by which dispersibility did not fall and was stabilized by this is acquired. Moreover, in order to rub the aggregation-service-ized particle against a substrate efficiently, when the organic acid was added, it turned out that a polish rate improves. This is because maintenance of the scouring pad of a particle is improved.

[0015] When using a pel OKISONI ammonium sulfate or hydrogen peroxide solution as an oxidizer, it turned out that it is not necessary to change pH of the slurry for CMP in 4-9 further again.

[0016] Therefore, according to the CMP method using such a slurry and this, high selectivity between the stable polish properties, insulator layers, and electric conduction film near neutrality and control of dishing can be realized now.

[0017]

[Embodiment of the Invention] Hereafter, the gestalt (henceforth an operation gestalt) of operation of this invention is explained, referring to a drawing.

[0018] (1st operation gestalt) Drawing 1 is the process sectional view showing the formation approach of aluminum DAMASHIN wiring concerning the 1st operation gestalt of this invention.

[0019] First, it is SiO₂ as an interlayer insulation film on the silicon substrate 1 in which the component (un-illustrating) was formed as shown in drawing 1 (a). The film 2 is deposited.

[0020] Next, it is SiO₂ as shown in drawing 1 (b). After forming a wiring gutter 3 in the front face of the film 2, the aluminum film 4 with a thickness of 600nm filled up with the interior of a wiring gutter 3 is deposited on the whole surface.

[0021] Finally, as shown in drawing 1 (c), aluminum DAMASHIN wiring 4 is completed by removing the surplus exterior [of a wiring gutter 3] aluminum film 4 by CMP [pH] the polish particle was using the mixed-crystal particle of a silica and an alumina, and using the slurry of 7.

[0022] It is SiO₂ only at changing the alumina concentration [%] (an alumina / silica mixed-crystal ratio) of the alumina to a silica, as shown in drawing 2 if the slurry of this operation gestalt is used. The selection ratio (aluminum polish rate / SiO₂ polish rate) of aluminum film to the film can be controlled now.

[0023] For example, the mixed-crystal particle of the silica and alumina whose alumina concentration is 10% and whose silica concentration is 90% (solid content: 3wt%), If pH performs CMP on condition that load:300 g/cm², number of top ring rotations:60rpm, and number of table rotations: 100rpm using the slurry of 7 SiO₂ The selection ratio of aluminum film to the film is set to 106 (=aluminum polish rate : 159 [nm/min]/SiO₂ polish rate : 1.5 [nm/min]).

[0024] Since only about 30 selection ratio can be taken in the conventional CMP, according to this operation gestalt, compared with the former, a high selection ratio will be obtained 3 or more times. Therefore, according to this operation gestalt, compared with the former, web thinning can realize now aluminum DAMASHIN wiring 4 small enough. Moreover, the increment in dishing can also be effectively controlled so that the 2nd operation gestalt may explain to a detail.

[0025] Moreover, according to this operation gestalt, it becomes possible to make slurry concentration low, maintaining a polish rate quicker than before, since the quick polish rate was obtained compared with the former. If slurry concentration can be made low, the part cost can be reduced, and the amount of abolition of a slurry will become less, and a process gentle to will become possible to an environment.

[0026] (2nd operation gestalt) Drawing 3 is the process sectional view showing the formation approach of aluminum DAMASHIN wiring concerning the 2nd operation gestalt of this invention. This example explains the formation approach of aluminum DAMASHIN wiring which used Nb film as liner film.

[0027] First, as shown in drawing 3 (a), the SOG film 12 as an interlayer insulation film is deposited on a silicon substrate 11, and then a wiring gutter 13 is formed in the front face of the SOG film 12. So far, except for the class of interlayer insulation film, it is the same as the 1st operation gestalt.

[0028] Next, as shown in drawing 3 (b), after depositing Nb liner film 14 with a thickness of 30nm on the whole

surface, the aluminum film 15 with a thickness of 600nm filled up with the interior of a wiring gutter 13 is deposited on Nb liner film 14.

[0029] As shown in drawing 3 (c), a polish particle Next, the mixed-crystal particle of a silica (40%) and an alumina (60%) (solid content: 0.5wt%), pH a pel OKISONI ammonium sulfate as 5-6.5, and an oxidizer 1%, The included slurry which is included is used. the qunaldinic acid for raising the holding power of the particle on a pad, and oxidization control -- 0.05wt(s)% -- Load: By 300 g/cm², number of top ring rotations:60rpm, number of table rotations:100rpm, and CMP of the conditions for polish time amount:2 minutes, grind the aluminum film 15 until the front face of Nb liner film 14 appears.

[0030] The reason using the slurry which contains a pel OKISONI ammonium sulfate and qunaldinic acid at this process is that it can polish speed up [of the aluminum film 15].

[0031] when an oxidizer is added to the slurry of the conventional silica base, and the slurry of the alumina base, respectively, specifically, it is shown in drawing 4 -- as -- the polish rate of aluminum film -- respectively -- at most -- when a pel OKISONI ammonium sulfate and qunaldinic acid are added to being 200 nm/min and 280 nm/min to the slurry using the mixed-crystal particle of a silica and an alumina as a polish particle, the polish rate of aluminum film serves as 700 nm/min. That is, according to this operation gestalt, a twice [over the past] as many polish rate as this is obtained.

[0032] The thickness of the aluminum film 15 is usually 600-800nm. On the other hand, if it is desirable that it is about 2 minutes, therefore the polish time amount of the aluminum film 15 does not use the slurry of this operation gestalt from a viewpoint of a throughput, it can be said that it is difficult to remove the surplus aluminum film 15 as it is also at such desirable polish time amount.

[0033] Moreover, the pel OKISONI ammonium sulfate which is an oxidizer also has the advantage of not changing pH of a slurry. The effectiveness described above is acquired also when hydrogen peroxide solution is used as an oxidizer.

[0034] Moreover, although dishing will keep close in the aluminum film 15 which is one of the problems of the conventional technique greatly if the process of drawing 3 (c) is performed using the conventional slurry, according to this approach, generating of dishing can be controlled effectively.

[0035] When exaggerated polishing (just +50%) is actually performed and the wiring width-of-face dependency of dishing is investigated, as shown in drawing 5 , according to this approach, dishing can be held down about [conventional] in 1/5.

[0036] As this result is shown in drawing 6 , it is thought that the mixed-crystal particle (this invention) of a silica and an alumina is because the increment in the polish rate to the load dependency of a polish rate, i.e., the increment in a load, is large compared with the conventional polish particle.

[0037] The reason is as follows. Polish of aluminum film 15 top face in a wiring gutter 3 advances by the elastic deformation of a pad during polish. This section section is a low load fundamentally, and, on the other hand, they are high loads, other parts 12, i.e., SOG film. Therefore, DISHINGU will become small like a slurry with a slow polish rate, so that a load is low.

[0038] Therefore, like the mixed-crystal particle of a silica and an alumina, if the increment in the polish rate to the increment in a load is a slurry using a large polish particle, generating of dishing can be controlled effectively.

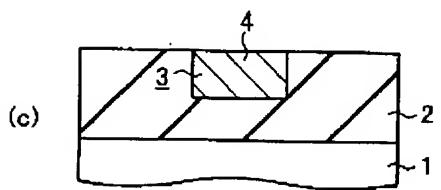
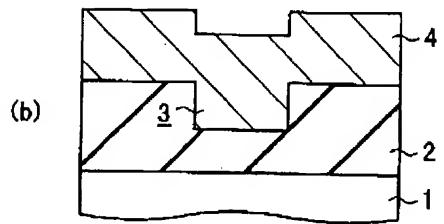
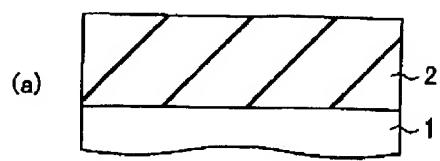
[0039] Moreover, since the mixed-crystal particle of a silica and an alumina has the quick polish rate on the SOG film 12 (it is polish rate 700 nm/min at load 300 g/cm²), it comes to be able to shorten exaggerated polishing time amount.

[0040] Finally, as shown in drawing 3 (d), dry etching, such as CMP or CDE, removes the external surplus aluminum film 15 and external Nb liner film 14 of a wiring gutter 13, and aluminum DAMASHIN wiring 15 is completed.

[0041] Here, in removing by CMP, it uses the slurry in which for example, a polish particle contains the mixed-crystal particle (solid content: 3Wt%) of a silica (40%) and an alumina (60%), and qunaldinic acid 0.05%.

[0042] In the so-called touchup CMP (for example, CMP of drawing 8 (c)), in order to aim at taking the remainder of the metal membrane of a crevice, and the blemish of the wiring section and the insulator layer section, a soft scouring pad is used. For this reason, dishing will arise greatly. For example, it carries out on condition that load 300 g/cm², number of top ring @ ** 60rpm, and 100 table @ **.

[0043] In the slurry of this invention, since a dishing rate can be made smaller than the polish rate on the field as shown in drawing 7 , small DAMASHIN wiring of erosion can be formed. This is considered for ***** to the slot of free grain where the interaction of a scouring pad and a polish particle becomes large, and causes dishing by qunaldinic acid to decrease.

Drawing selection [Representative drawing]

[Translation done.]

[0044] Moreover, the slurry does not need to contain the oxidizer. When removing by CDE, it is CF4 / O2 as reactant gas. Gas is used.

[0045] (3rd operation gestalt) Drawing 7 is the process sectional view showing the formation approach of W DAMASHIN wiring concerning the 3rd operation gestalt of this invention.

[0046] First, it is SiO2 as an interlayer insulation film on the silicon substrate 21 in which the component (un-illustrating) was formed as shown in drawing 8 (a). The film 22 is deposited and then it is SiO2. A wiring gutter 23 is formed in the front face of the film 22.

[0047] Next, as shown in drawing 8 (b), after depositing Ti liner film 24 with a thickness of 30nm on the whole surface, and forming the TiN liner film 25 in the front face of Ti liner film 24 by 500-degree C nitriding annealing continuously, the W film 26 with a thickness of 500nm filled up with the interior of a wiring gutter 23 is deposited on the TiN liner film 25.

[0048] Next, the W film 26 is ground until it uses the slurry of 3% of succinic acids, and 3% of silica (60%) alumina (40%) mixed-crystal particles for 3% of hydrogen peroxides, and an oxidation inhibitor as an oxidizer and the front face of the TiN liner film 25 appears by CMP using the slurry of the conditions of load 250 g/cm2, number of top ring @ ** 50rpm, and number of table @ ** 50rpm, as shown in drawing 8 (c).

[0049] Finally, as shown in drawing 8 (d), a polish particle uses the slurry of the mixed-crystal particle (solid content: 0.5wt%) of a silica (40%) and an alumina (60%). Load : by 300 g/cm2, number of top ring rotations:60rpm, number of table rotations:100rpm, and CMP of the conditions for polish time amount:1 minute The W film 26, the TiN liner film 25, and Ti liner film 24 are ground until the front face of a silicon substrate 1 appears, and W DAMASHIN wiring 26 is completed.

[0050] The polish rate of each film 22, 24, and 25 in the process of drawing 8 (d) has the desirable way which is not quick. In the case of the slurry used at the process of drawing 8 , the polish rate of each film 22, 24, and 25 is settled in the range of 10 - 20 nm/min, and a polish rate cannot become quick too much. Furthermore, each film 22, 24, and 25 can be ground on the same conditions, and an exaggerated polish margin can also be large and stable polishing without dishing or SHININGU can be realized now.

[0051] Moreover, according to this operation gestalt, although the strong acid of pH 1-2 was performing CMP of the conventional W film, since CMP of W film can be performed in the neutral region of pH5, there is also no problem of the corrosion of W film.

[0052] In addition, although reference was not made with the above-mentioned operation gestalt about the device with which this invention is applied, semiconductor memory, such as DRAM, is raised, for example. Furthermore, a logic mixed-loading circuit, a logical circuit, etc. are raised.

[0053] Moreover, the electric conduction film (aluminum film, W film) which is wiring is not what is limited to what was explained with the operation gestalt mentioned above. The single-level-metal film which consists of a metal chosen from the metal group which consists of W, Ti, Mo, Nb, Ta, and V, or Cu, The laminated metal film chosen from the metal group which consists of aluminum, W, Ti, Mo, Nb, Ta, and V or the alloy film which uses as a principal component the metal chosen from the above-mentioned metal group, a nitride, the HOU-ized film, or an oxide film can also be used. It becomes possible to prevent dishing and SHININGU by changing the mixed-crystal ratio of an alumina and a silica in any case of the electric conduction film.

[0054] Moreover, it is more desirable to form the oxide film in the front face of the electric conduction film which should be ground beforehand, in case CMP is performed.

[0055] Moreover, although the above-mentioned operation gestalt explained the case of DAMASHIN wiring, this invention is effective also to dual DAMASHIN wiring.

[0056] In addition, in the range which does not deviate from the summary of this invention, it deforms variously and can carry out.

[0057]

[Effect of the Invention] As explained in full detail above, according to this invention, the slurry for CMP and the CMP method the high selectivity between the stable polish properties, insulator layers, and metal membranes near neutrality and control of dishing are realizable can be realized now by using the mixed-crystal particle of a silica and an alumina as a polish particle.

[Translation done.]